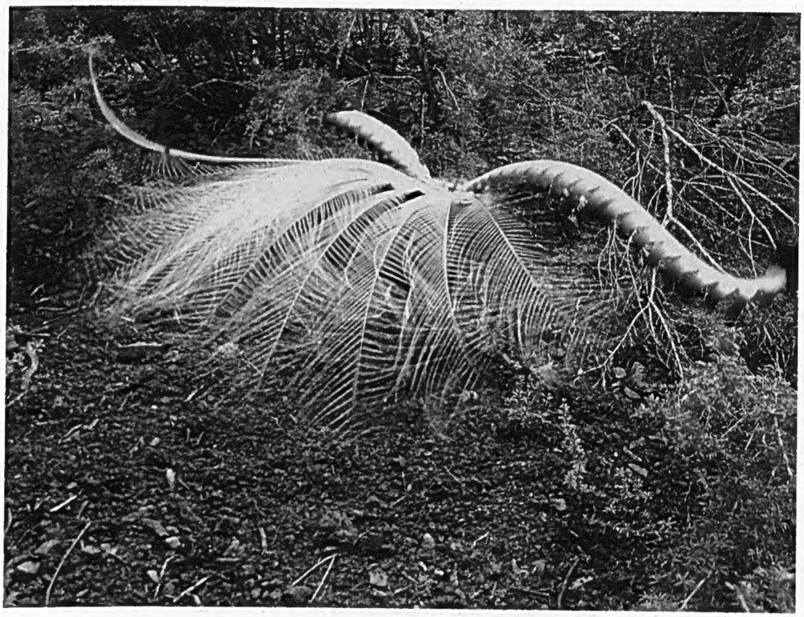
The Victorian Naturalist

Volume 139 (5) October 2022



Published by The Field Naturalists Club of Victoria *since 1884*

The Victorian Naturalist
is published six times per year by the

Field Naturalists Club of Victoria Inc

Registered Office: FNCV, 1 Gardenia Street, Blackburn, Victoria 3130, Australia.
Postal Address: FNCV, 1 Gardenia St, Blackburn, Victoria 3130, Australia.
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Volume 139 (5) 2022 October

Editors: Gary Presland, Maria Gibson, Sue Forster

Assistant Editor: Virgil Hubregtse

ISSN 0042–5184

Front cover: Male Superb Lyrebird *Me*... ...*hollandiae* displaying on its mound. Photo Frank Pierce.
Back cover: Female Superb Lyrebird ... ...ng. Photo Frank Pierce.

Small skink, expanding property portfolio: A range extension of Grey's Skink *Menetia greyii* in Victoria

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Abstract
Grey's Skink *Menetia greyii* is reported from 2 locations in grassland vegetation at Mount Cottrell on the Keilor Plains of southern Victoria. These records represent the most southern detections of this species, and the first reported south of the Great Dividing Range. One lizard was collected in a pitfall trap, the other under a roof tile, both within Natural Temperate Grassland dominated by Kneed-spear Grass *Austrostipa bigeniculata* and Kangaroo Grass *Themeda triandra*. (*The Victorian Naturalist* 139(5), 128–132)

Keywords: *Menetia*, Victoria, range, grassland, Common Dwarf Skink

Introduction
Grey's Skink *Menetia greyii* (also known as the Common Dwarf Skink) is Australia's smallest lizard species (Fig. 1). The species has a snout-vent length up to 38 mm but is more commonly less than 30 mm (Robertson and Coventry 2019). The species is widespread in all mainland states and territories but absent from Tasmania. In Victoria, records are concentrated in the northwest, with isolated records in the far east and north of the Great Dividing Range (GDR; Fig. 2), generally in areas with less than 650 mm annual rainfall. There are records from 13 of the 28 Victorian bioregions, occupying a variety of ecosystems, including Dry Sclerophyll Forest, Box-Ironbark Forest, Red Gum, Mallee, Black Box Woodland, Pine-Buloke Woodland, Heathland and Grassland (Robertson and Coventry 2019).

The species is diurnally active and commonly observed in the litter layer (Cogger 2018). It has a broad diet of small invertebrates, including true bugs, spiders, termites, and silverfish (Pianka 2011). Breeding occurs over Spring–Summer with, generally, one clutch of 1–3 eggs laid each year, although some individuals may produce 2 clutches (Smyth and Smith 1974). It is the only Australian skink known to undergo parthenogenesis (Adams et al. 2003), although this has not been reported in Victoria (Robertson and Coventry 2019).

New records
Two records of *M. greyii* are reported from the Mount Cottrell area, west of Melbourne, 3 km apart. One specimen was recorded from a pitfall trap (37.7571° S, 144.6444° E), on 29 November 2019 during an invertebrate survey in the Western Grassland Reserve, a new reserve being established by the Victorian Government (Department of Environment, Land, Water and Planning [DELWP] 2015; Sinclair and Atchison 2012). The other was recorded under a roof tile (37.7516° S, 144.6110° E), on 18 November 2021, as part of a fauna survey. Both locations are in the Victorian Volcanic Plain bioregion, with only one previous record of this species from this bioregion, near Ballarat.

The lizards were recorded in largely treeless native grassland, which was once widespread on the basalt terrain of the Keilor–Werribee plains (Sutton 1917; Stuwe and Parsons 1977). Early accounts confirm that the pitfall collection location was essentially treeless at the time of European invasion, while the tile record was near the margins of treeless grassland and dry sclerophyll forest (Sinclair and Atchison 2012). The grassland vegetation community has been

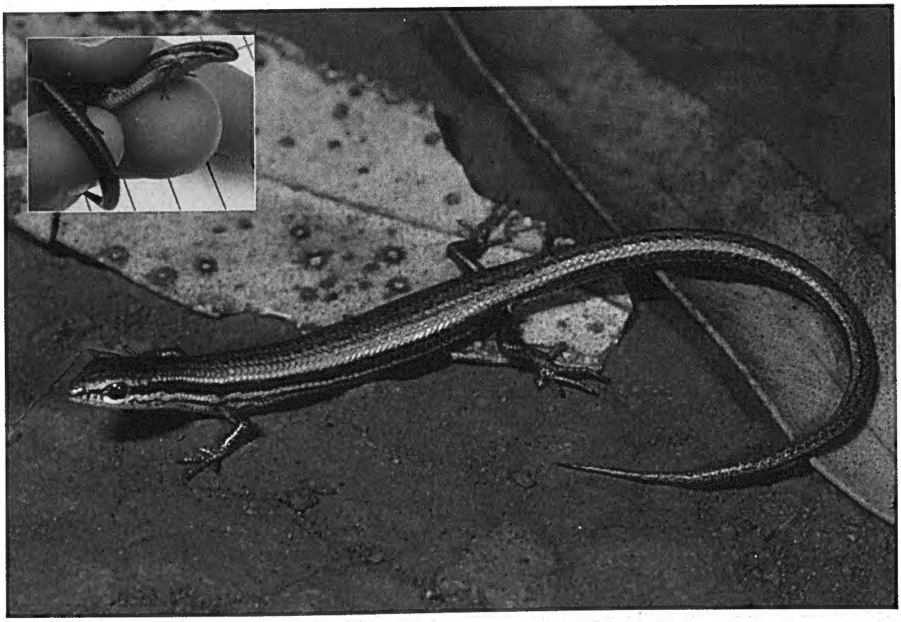

Fig. 1. Grey's Skink *Menetia greyii* and, inset, the roof tile specimen recorded at Mount Cottrell. Main photo Peter Robertson; inset Candice Sexton.

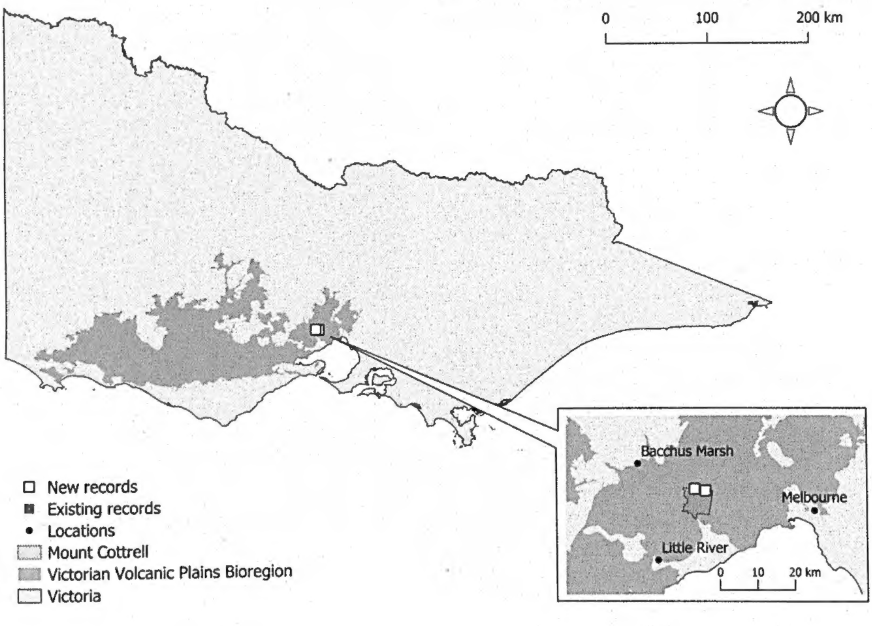

Fig. 2. Records of *Menetia greyii* within Victoria. Source: Victorian Biodiversity Atlas and Atlas of Living Australia.

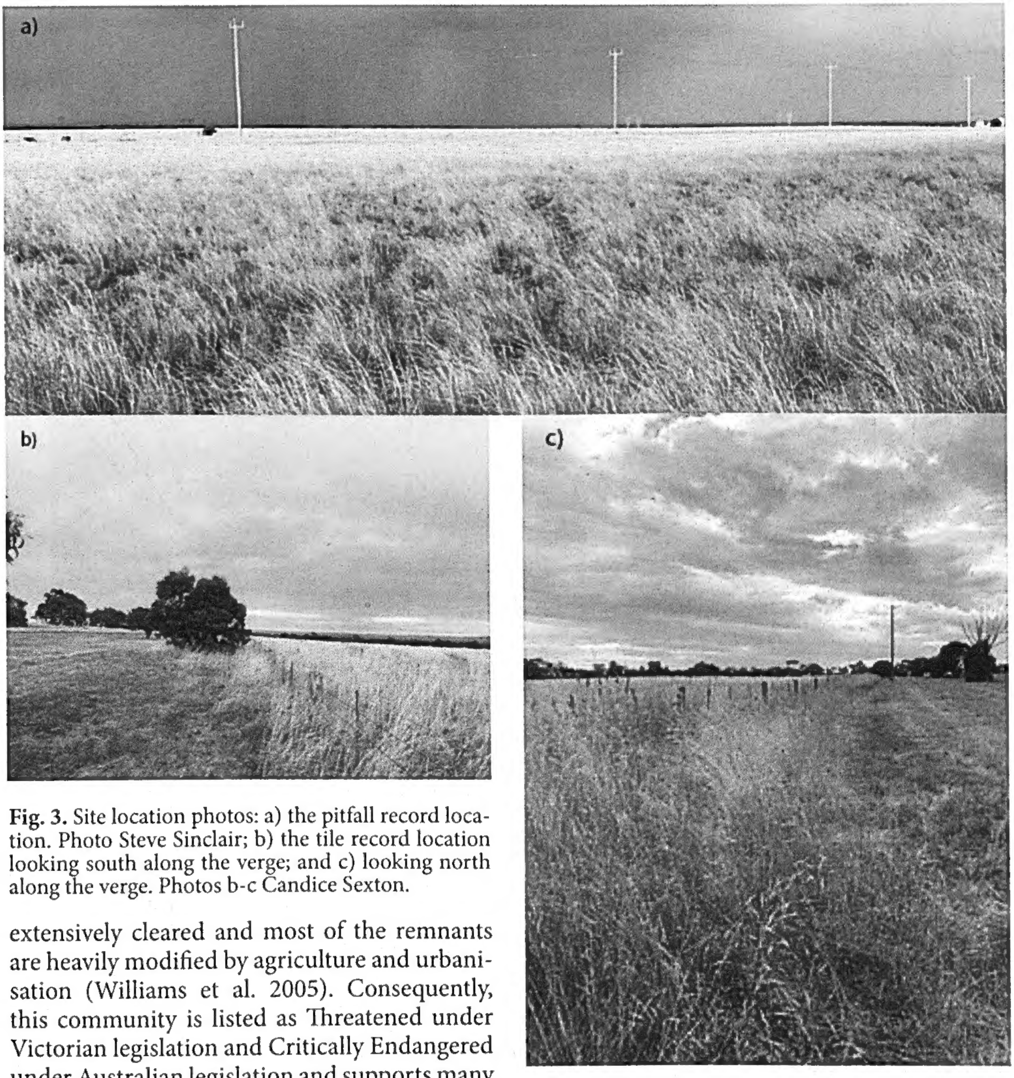

Fig. 3. Site location photos: a) the pitfall record location. Photo Steve Sinclair; b) the tile record location looking south along the verge; and c) looking north along the verge. Photos b-c Candice Sexton.

extensively cleared and most of the remnants are heavily modified by agriculture and urbanisation (Williams et al. 2005). Consequently, this community is listed as Threatened under Victorian legislation and Critically Endangered under Australian legislation and supports many listed threatened species (Vranjic 2008).

Other reptile species recorded collectively from the sites were Eastern Blue-tongued Lizard *Tiliqua scincoides*, Large Striped Skink *Ctenotus spaldingi*, Striped Legless Lizard *Delma impar*, Tussock Skink *Pseudemoia pagenstecheri*, Eastern Brown Snake *Pseudonaja textilis* and Eastern Tiger Snake *Notechis scutatus*.

The pitfall record originated from a site that is relatively intact compared to the broader surrounding area (Fig. 3a). Vegetation sampling using point-intercept sampling was undertaken at the site in the same season as the record, revealing vegetation dominated by Kneed-spear Grass *Austrostipa bigeniculata* (65% cover) and Kangaroo Grass *Themeda triandra* (32% cover). Although the property has a long history of stock grazing, it supports many plant species indicative of a relatively benign grazing history, including Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*). Exotic annual grasses (8% cover), Serrated Tussock *Nasella trichotoma* (5% cover) and exotic forbs (5% cover) are the predominant weeds. The site has never been cropped and retains natural basalt rocks on and near the soil surface. In the year of sampling,

organic litter covered 11% of the site, with rock, moss, and bare ground all less than 1% cover.

The roof tile record originated from within a public roadside verge that is regularly disturbed by slashing of vegetation (Fig. 3b–c). The skink was detected under a terracotta roof tile, installed as artificial habitat for survey purposes. The vegetation community is comparable to that of the pitfall record site, being dominated by Kneed-spear Grass and Kangaroo Grass. Predominant weeds include annual grasses and *Nasella trichotoma*. Natural basalt rock has largely been removed from the roadside verge but has been retained within the adjacent private property.

There are no soil data from the precise location of the records, but nearby (<3 km) samples (n=6) from the same terrain and land unit (i.e. the lower slopes of Mount Cottrell) are classified as grey-brown or brown-grey 'clays' or 'very heavy clays', with up to 5% gravel. These soils tend to form deep cracks when dry.

The closest previously reported records for the species are 98 km to the north (Victoria Biodiversity Atlas record Project Id 2580, Survey ID 923834, Location: Heathcote–Graytown National Park, 2003 and 2004); 70 km to the west-northwest (Atlas of Living Australia record ID 293c8f78-d8a6-4e13-a912-b096ac-812cba, Location: Ballarat, accuracy not listed, 1905). Our records represent the most southern records of this species to date and the first south of the GDR.

These records fit a broader biogeographic pattern. The rain-shadow of the Otway Ranges, southern Victoria, restricts rainfall on the Keilor Plains (west of Melbourne), with some locations receiving less than 450 mm annually, so that the conditions are more similar to northern Victoria than most other areas south of the GDR. Many native plants have distributions largely north of the GDR, but with outlying occurrences on the Keilor Plains (e.g. Buloke *Allocasuarina luehmannii* and Black Roly-poly *Sclerolaena muricata*).

A Habitat Distribution Model (https://www.ari.vic.gov.au/research/modelling/habitat-distribution-models-hdms) for *M. greyii* predicts the habitat availability of the Keilor Plains to be low for this species but comparable to other areas, such as the Wimmera, which have yielded records (Fig. 4). The model's output largely

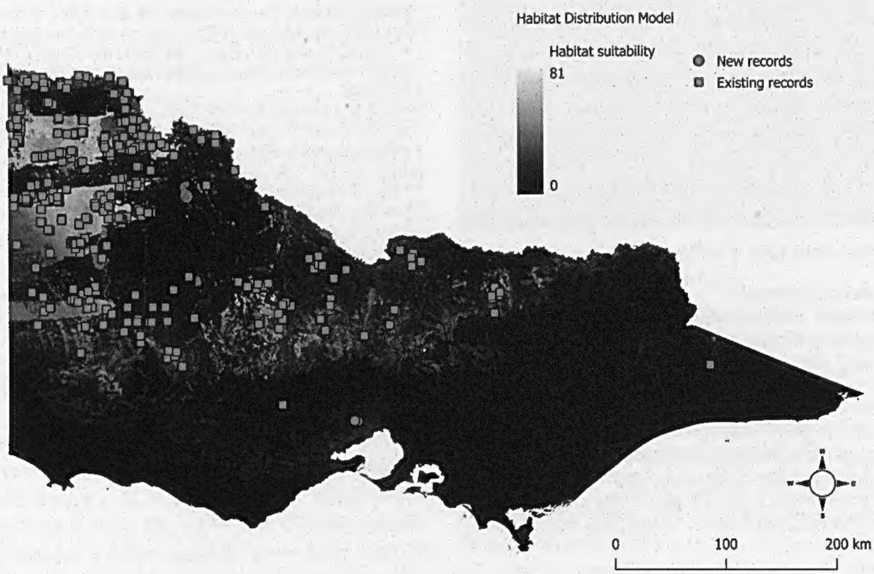

Fig. 4. Predicted habitat suitability for *Menetia greyii* within Victoria based on a DELWP Habitat Distribution Model.

reflects the known distribution of the species, with habitat suitability increasing north of the GDR and limited predominantly to areas with less than 650 mm annual rainfall. Only 2 records are known from the GDR, the 'Ballarat' record, and an isolated record from within the Snowy River National Park near Gelantipy, which combined with the records reported here from south of the divide stand out as being disjunct from the species' main range.

As for similar recently reported reptile range extensions e.g. Millewa Skink *Hemiergis millewae* (Nimmo et al. 2008), Spencer's Skink *Pseudemoia spenceri* (Homan 2011), it is unknown whether these records constitute part of previously undetected disjunct populations, are part of a broader continuous population, or represent recent human-facilitated introductions. The discovery of a disjunct population of Spencer's Skink on the Victorian Volcanic Plain north of Melbourne in 2010 (Homan 2011), was deemed to have been accidentally transported to the location before becoming established. The small size of Grey's Skink as well as its broad geographic range could facilitate the unintentional translocation of this species.

Irrespective of the origin of *M. greyii* in the Mount Cottrell area, the reporting of 2 specimens, both within grassland habitat only 3 km apart, suggests the likelihood of a larger population in the area. Ongoing monitoring of the broader location of our records as part of the Melbourne Strategic Assessment program (DELWP 2015), as well as any future records from other surveys or observations, may further illuminate the status of *M. greyii* on the Victorian Volcanic Plains.

Acknowledgements

We gratefully acknowledge Khorloo Batpurev (ARI) for providing vegetation cover data; Nick Clemann (ARI) and Peter Robertson (Wildlife Profiles Pty Ltd) for confirming the identification of the *M. greyii* specimens; Peter Robertson for allowing use of his photo of *M. greyii* and providing feedback on the manuscript; Ken Walker (Museums Victoria) for providing details of the 'Ballarat' record; Matt White and Nevil Amos (both ARI) for providing and interpreting the Habitat Distribution Model; Michelle Kohout, Matt Bruce and Khorloo Batpurev (all ARI) for assisting in the field; Geoff Brown (ARI) for his insightful comments on the manuscript; and the Melbourne Strategic Assessment program; Greater Western Water, Jacobs Group (Australia) Pty Ltd and Wildlife and Ecology Consulting for funding and arranging the pieces of work that resulted in these records. This work was conducted under Wildlife Research Permit No's. 10008640 and 10009539.

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Received 3 March 2022; accepted 2 June 2022

Long-term survey on private property near Buchan, East Gippsland, Victoria, sheds light on Sambar Deer *Cervus* (*Rusa*) *unicolor* behaviour

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Abstract
Although presenting a small and largely opportunistic study on a private property near Buchan, East Gippsland, Victoria, this paper presents a number of insights on Sambar Deer *Cervus* (*Rusa*) *unicolor* behaviour. Results reflect patterns occurring elsewhere in the state, such as the annual increase in Sambar up to 2019 and their migration back and forth from higher elevations to lower elevations in response to snow cover. Sambar were more tolerant of the surveyor on a quad-bike than when on foot, and identification of distinctive individuals indicated habituation with subsequent surveys. A large decrease in Sambar occurred in 2021 and is attributed to the Black Summer bushfires of 2019/2020 and subsequent culling of Sambar but the extent of the contributions of each remains unclear. (*The Victorian Naturalist* **139**(5), 133–141)

Keywords: effects of fire and culling, habituation, migration, surveys by quad-bike, *Rusa unicolor*

Introduction

Sambar Deer *Cervus unicolor* (nomenclature follows Jackson and Groves 2015), also known as *Rusa unicolor*, is a crepuscular species (Bentley 1998; Davies 2020; Comte 2022), active at dawn and dusk, and has been described as wary, shy, cryptic, and difficult to observe (Sambar deer habitat use and movement study Alpine National Park 2020) (Fig. 1). Although large (typically, male and female adults weigh 220 and 140 kg respectively; Bentley 1998; Moriarty 2004), these animals are well camouflaged and highly mobile, actively avoiding detection (Bentley 1998; Davies et al. 2020; Comte 2022). A number were imported into Australia from India and Sri Lanka (Bentley 1998) and were introduced into Victoria by the Acclimatisation Society of Victoria in the 1860s. They were released at 4 sites near Melbourne: Mt Sugarloaf near Kinglake (1863), Snake Island at Corner Inlet (1866), Gembrook (undated) and the area presently known as Tooradin (1868–1873) (Bentley 1998; Forsyth et al. 2015). Anecdotal evidence suggests these populations merged but remained west of the Great Divide and Strzelecki Ranges. It is believed the species was forced east during the 1939 Black Friday Bushfire (Bentley 1998). Sambar were first seen in the Buchan–Gelantipy region in 1965 (Bentley 1998: Forsyth et al. 2015). They have now colonised the Great Dividing Range throughout central and eastern Victoria and have spread into south-eastern New South Wales and the Australian Capital Territory (Moriarty 2004; Bennett 2015).

Fig. 1. Male Sambar Deer *Cervus unicolor* on private property near Buchan, Victoria.

Deer are a threat to biodiversity in native vegetation, causing a decline of deer-preferred plant species, loss of plant biomass, declines in plant diversity and compromised regeneration of plants (Davis et al. 2016; Department of Environment, Land, Water and Planning [DELWP] 2020). Deer are responsible for physical damage caused by tramping, wallowing,

thrashing and rubbing (Davis et al. 2016; Department of Climate Change, Energy, the Environment and Water 2021). The agricultural threats posed by deer include damage to fences, and selective browsing of trees, pasture and fruit and vegetable crops (Lindeman and Forsyth 2008). Deer also are potential vectors of livestock disease (Cripps et al. 2018).

In 2007, the reduction in biodiversity of native vegetation by Sambar was listed as a potentially threatening process under the *Flora and Fauna Guarantee Act 1988*. At this time, Sambar were considered a threat to at least 13 already threatened plant species and 12 ecological communities, including already threatened Alpine Sphagnum Bogs and associated fens (DELWP 2020). On a private property near Buchan in East Gippsland, Victoria, Sambar ringbarked and killed emerging tree regrowth through antler rubbing (pers. obs. 1998–2021). They also fouled the creek running through the property by wallowing. Sambar were actively stalked for removal from the property since 1998 but were rarely seen (pers. obs. 1998–2012); however, personal (JG) diary records showed a clear increase in Sambar sightings in 2012. It was, therefore, decided to quantify Sambar numbers on the property to determine changes in population numbers over time.

Methods

Study site

The study took place on 120 ha of marginal farmland (37° 22' S, 148° 8' E; 500 m ASL) on the seaward side of The Great Dividing Range. The nearest town was Buchan in East Gippsland, Victoria. The survey site was heavily wooded with upper-storey trees comprising Yellow Box *Eucalyptus melliodora*, Grey Box *E. microcarpa*, Mountain Grey Gum *E. cypellocarpa*, Red Stringybark *E. macrorhyncha* and Yellow Stringybark *E. muelleriana*. Mid-storey trees were Blackwood *Acacia melanoxylon*, Lightwood *A. implexa* and Silver Wattle *A. dealbata*. The understorey consisted of Common Cassinia *Cassinia aculeata* and Burgan *Kunzea phylicoides*. Frying Pan Creek, a tributary of the Buchan River, flowed through the study site. As well as Sambar, other herbivores observed regularly were Grey Kangaroo *Macropus giganteus*, Swamp Wallaby *Wallabia bicolor* and Red-necked Wallaby *Wallabia rufogriseus*. The site ran 30 farmed goats for weed control and was enclosed by a well-constructed 1.1 m high electric wild dog exclusion fence. The site was wild dog free throughout the study and has remained so for over twenty years.

The survey site was affected twice by bushfire. In spring 2017, a bushfire burnt 20% of the site. In 2019/2020, 80% of the site was burnt in the Black Summer Bushfires. The survey site was on the northern perimeter of the Black Summer East Gippsland (BSEG) Fires. These fires burnt 1 363 100 ha, more than half of the East Gippsland Local Government Area (LGA) (Community Bushfire Connection 2022). The BSEG fires were started by lightning strikes on 21 November 2019, after more than 3 years of drought. The last of the fires in the LGA were put out on 27 February 2020 (Community Bushfire Connection 2022).

Surveys

Surveys were conducted from 2013 to 2021 inclusive, from May to September inclusive, which is when Sambar usually exhibit sexual behaviour at the study site and when the species is most visible in the area (pers. obs. 1998 onwards). Although wallowing by Sambar may occur all year (Comte 2022), wallowing at the study site correlated with sexual behaviour (pers. obs. 1998 onwards), so active wallows indicated breeding was in progress. The surveys were performed on a quad-bike travelling at approximately 10 kph on a route totalling 5.4 km. The route followed a ridgeline down to and along creek flats, where the majority of Sambar were recorded, and returned up the ridgeline, taking 40 minutes to complete. Much care was taken to avoid recording the same Sambar twice in any individual survey. When there was any doubt, the sighting was not recorded. All Sambar recorded were identified by eye and confirmed with binoculars where necessary. Surveys were taken opportunistically, thus numbers of surveys varied from month to month and from year to year (Table 1).

Each survey commenced at local sundown, which was 30 minutes before true sundown owing to the presence of hills west of the survey area. Previous Sambar stalking on the site had shown the species to be more approachable

Table 1. The number of monthly and yearly quad-bike surveys, yearly walking surveys, and yearly cull numbers of Sambar Deer on private property, Buchan, Victoria.

	Number of Surveys							Sambar culled
	Quad-bike						Walking	
Year	May	June	July	Aug.	Sept.	Total per annum	Total per annum	Total per annum
2013	16	14	24	23	21	98	63	1
2014	8	16	23	22	22	91	65	3
2015	23	20	24	22	22	111	54	4
2016	17	17	18	24	12	88	62	12
2017	17	18	21	23	23	102	63	6
2018	23	23	20	27	20	113	65	0
2019	22	25	28	26	24	125	74	4
2020	28	26	27	27	22	130	101	6
2021	24	21	25	24	23	117	85	5

at sundown than any other time (pers. obs. 1998–2012). The majority of Sambar were feeding when recorded.

Opportunistic counts of Sambar sightings also were taken during morning walks, which were for exercise, thus, the number of counts (surveys) varied from year to year (Table. 1). The route was similar to that taken with the quad-bike except that it followed a gully rather than the ridge line, included approximately 250 m less of the creek flats and was a round trip rather than out and back along the same track. The walks did not stick to the vehicular track, were not restricted to any one particular time of the morning, were about 4 km long and took about 50 minutes to complete.

Culling

One or more opportunistic culls of Sambar occurred throughout the survey period each year except for 2018 (Table 1) and may have influenced the results. For ease of retrieval, any Sambar culled were chosen by their proximity to a track rather than by sex or size. This was an attempt to reduce the damage caused by the Sambar on the site. Culling by ground-shooting was done by a licenced deer-shooter, along a vehicular track. Usually, 2 people were involved to enable loading of the carcass on a vehicle for removal from the property.

Results

Quad-bike surveys

Over 9 years, 975 surveys and a total distance travelled of 5265 km, there were 2874 Sambar Deer sightings. The mean number of Sambar per survey per year generally increased over the study period, although a marked drop occurred in 2021 (Fig. 2). In 2016, a drop in the mean number of Sambar per survey is suggested but there were considerably more Sambar culled in this year than in others (Table 1), which may explain, at least in part, the decrease in sightings.

In 2013, Sambar occurred in 60% of surveys (Table 2); however, the number of surveys with Sambar increased with time and, in 2020, Sambar were observed in 99% of surveys (Table 2). By contrast, in 2021, Sambar were observed in only 34% of surveys—a marked decrease in sightings. The maximum number of Sambar per survey increased from 7 in 2013 to 18 in 2020, but dropped to only 4 in 2021 (Table 2). The first occurrence of ≥ 10 Sambar per survey occurred in 2015, in 3.6% of surveys (Table 2). In 2020, ≥ 10 Sambar per survey occurred in 13.5% of surveys (Table 2).

September was notable for the higher numbers of Sambar observed and this occurred in 7 of the 9 months of each year's study period (Fig. 3). In 2014 and 2018, higher numbers of Sambar were sighted in June and July. Also in September, Sambar were regularly observed in larger groups (pers. obs. 2013–2021).

Walking surveys

Over the study period, there were 632 walking surveys totalling a distance of 2528 km and 275 Sambar sightings. Mean annual numbers of Sambar seen on walks (Fig. 4) were considerably less than those seen on quad-bike surveys. Furthermore, compared to the quad-bike

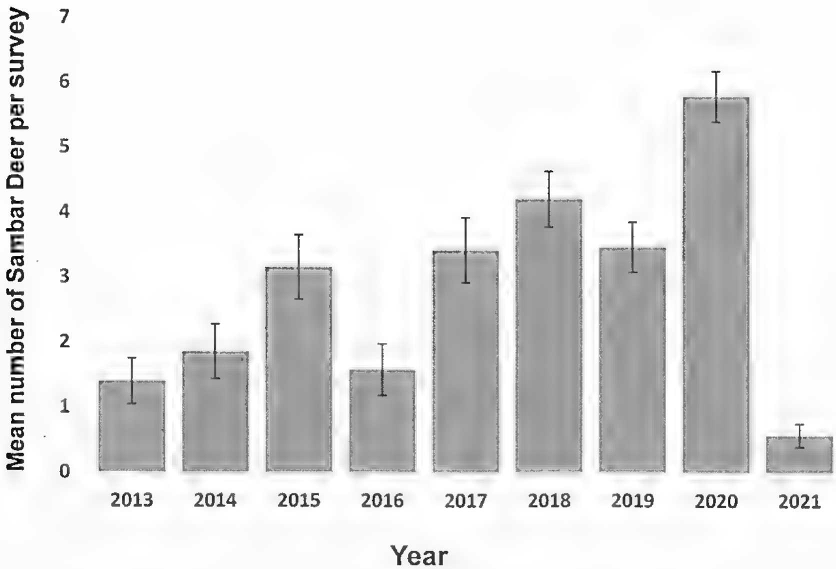

Fig. 2. Mean number of Sambar Deer per quad-bike survey each year from 2013 to 2021 on private property, near Buchan, Victoria, with 95% confidence intervals.

Table 2. Sambar Deer sightings for quad-bike surveys from 2013 to 2021, on private property near Buchan, Victoria.

Year	% surveys with Sambar	Maximum number of Sambar per survey	Number of surveys with the maximum number of Sambar	% surveys with ≥ 10 Sambar
2013	60	7	3	0
2014	70	9	2	0
2015	82	12	1	3.6
2016	71	12	1	1.1
2017	89	14	1	0.9
2018	97	11	1	1.7
2019	93	11	1	0.7
2020	99	18	1	13.5
2021	34	4	2	0

surveys, the walking surveys did not show the same increase in Sambar sightings over the years. A marked decrease in Sambar sightings in 2021, also observed during quad-bike surveys, was particularly notable.

Discussion

Increase in Sambar Deer

Personal (JG) diary records indicated a distinct increase in Sambar Deer sightings at the study site in 2012, prompting this investigation. This was in spite of active stalking of Sambar since 1998 in an attempt to rid the property of these animals. A body of evidence indicates this increase in Sambar numbers ran parallel to that occurring elsewhere in Victoria. In eastern Victoria, Forsyth et al. (2018) identified an increase of Sambar in diets of Dingo *Canis familiaris* dingo and European Red Fox *Vulpes vulpes*, i.e. Sambar remains did not occur in scats of either species in 1984 but, in 2013, Sambar occurred in 8.2% and 0.5% of scats for Dingo and Fox respectively. The increase was particularly notable from 2006 to 2013. In the same study, Forsyth et al. (2018) identified a greater than 4-fold increase in the number of Sambar harvested per

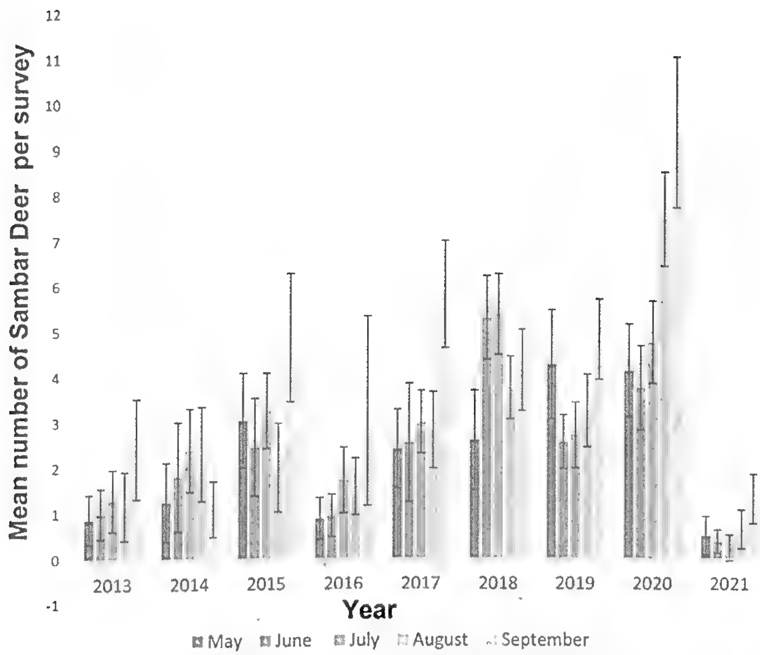

Fig. 3. Mean number of Sambar Deer per quad-bike survey each month from 2013 to 2021 on private property near Buchan, Victoria, with 95% confidence intervals.

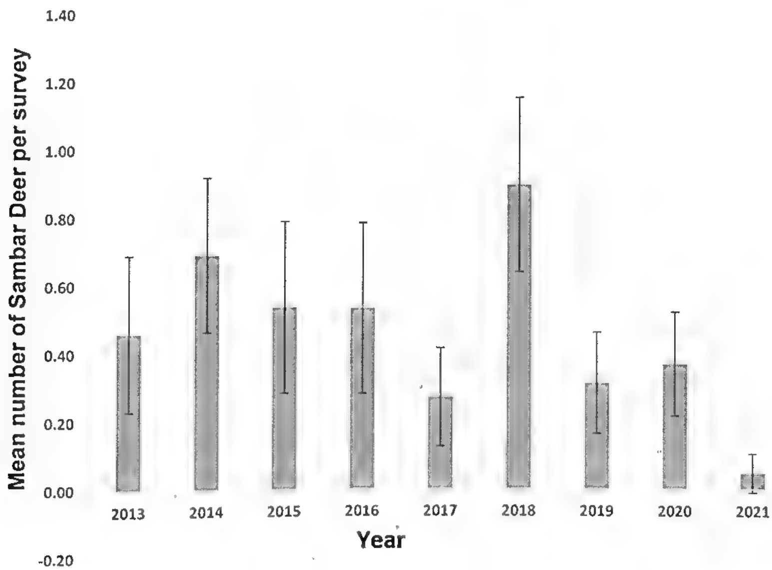

Fig. 4. Mean number of Sambar Deer per walking survey per year from 2013 to 2021 on private property near Buchan, Victoria, with 95% confidence intervals.

hunter-day (used as an index of Sambar abundance; see also Moloney et al. 2022) from 1984 to 2013. This increase in Sambar was, again, particularly notable from 2006 to 2013. Another study (Forsyth et al. 2012) identified an increase in Sambar numbers at Mount Buffalo National Park, Victoria, from 2007 to 2011.

In 2009, total deer (all species) harvested per hunter-day was 0.35 (Game Management Authority, SVGMA 2018) compared to 0.56 in 2016 (SVGMA 2017) and 0.58 in 2017 (SVGMA 2018). In turn, this represented a large increase in Sambar since 2009, as Sambar formed the vast majority of total deer harvested annually, e.g. ~83% in 2016 (SVGMA 2017), ~84% in 2017 (SVGMA 2018) and ~76% in 2019 (Moloney and Hampton 2020). Moloney et al. (2022) calculated an annual increase of 8.1% in hunter efficiency (harvest per hunting day) from 2009 to 2019, using data from surveys of deer hunters (stored by the SVGMA). This, again, would have translated to a large increase in Sambar during that time. Results of the quad-bike-surveys within this study (Figs 2 and 3; Table 2) also showed a large increase in Sambar numbers. Thus, Sambar have had a long-term increase in numbers, which could well be, or become exponential, as described by Moloney et al. (2022) for the number of deer (all species) harvested from 2009 to 2019.

Survey method and Sambar Deer habituation

Numbers of Sambar seen on walking surveys were significantly fewer than numbers seen on quad-bike surveys, i.e. 0.12 Sambar per km compared with 0.55 Sambar per km. This probably reflected time of day as walking surveys were carried out in the morning, at various times, while quad-bike surveys occurred at sundown, and most Sambar were seen at dusk. In the Upper Yarra Catchment, Bennett et al. (2015) also observed the majority of Sambar at dusk but noted some fed throughout the night and occasionally during the day. In Baw Baw National Park, Davies et al. (2020) noted seasonal (spring and early summer) crepuscular activity. Comte et al. (2022) also described a seasonal difference in behaviour; they found Sambar typically showed crepuscular behaviour, with most Sambar seen just before sunset, while a lower number were seen around sunrise but, in winter (July to September), most Sambar were observed during the day. In winter, female and juvenile sightings occurred in late morning and male sightings occurred in early afternoons. This change in the diel cycle coincided with the presence of snow at their study site.

Prior to 2013, the author noted Sambar were more approachable whilst he drove a quad-bike than when he was on foot. This difference in Sambar sensitivity to surveyor presence remained evident throughout the 2013 to 2021 surveys. Possibly, the heightened sensitivity of Sambar to a person on foot related to previous experiences of being hunted.

Deer are widely known to habituate to human presence (Sibbald et al. 2011). This was observed for a small proportion of Sambar during quad-bike surveys. Individuals of Sambar are very difficult to identify but, amongst those habituated, there were a number of stags with distinctive antler shape (altered due to damage, for example) and/or distinctive body scarring. Thus, they were easily recognised when present in subsequent surveys. Although most of these distinguishable Sambar fed during surveys, they initially stopped feeding and stood still when they first saw the surveyor. After several surveys, they stopped feeding when they saw/heard the surveyor's approach, stood still for a moment or two, but then resumed feeding. Eventually, they ignored the surveyor's approach and continued feeding without lifting their heads. Previously, this had never been witnessed by the author. Usually, the Sambar avoided humans and used cover or camouflage to hide, or they ran away (pers. obs. 1998–2021). This adaptive behaviour was displayed only during the quad-bike surveys and did not occur with any other encounters, possibly because hunting never involved use of quad-bikes and, so, Sambar did not perceive any danger.

Most Sambar did not show habituation in this study, although it is widely recognised in other deer species. There are many factors that determine whether an individual deer may or may not exhibit habituation, such as frequency of stimulus, individual personality traits, sex, age, group size, presence of juveniles, vegetation cover, weather and season, to name a few. These parameters are variously discussed by Sibbald et al. (2011); Hansen and Annes (2014); Price

et al. (2014); Sutton and Heske (2017). During this study, however, a possible contributing factor that explains why most Sambar did not show habituation is that they were migrating through the property. This is discussed in the following section.

Amos et al. (2014) and Forsyth et al. (2022) reviewed the various methods used for surveying deer and the many factors influencing choice of methodologies. Schult and Armstrong (1999) considered that if annual population estimates were carefully made the trends might be as important, if not more so, than actual numbers of deer. Although this study did not use the more sophisticated methods included in Amos et al. (2014) and Forsyth et al. (2022), the surveys carried out using a quad-bike have shown similar trends to other studies (e.g. Comte et al. 2022) and may prove useful for studies of similar terrain where cost is an issue.

Migration

The observations of habituation by Sambar, confirmed by presence of easily recognisable stags, provided evidence that the population at the study site changed every 3 to 4 weeks throughout the annual study period. This migration appeared to be related to winter weather events in the high country, such as snowfall below 1000 m. During the first 4 months of the annual surveys, Sambar appeared to migrate out of the Victorian high country 50 km north of the study site, through the study area, and toward a warmer environment. They then migrated back to the high country in September, explaining the higher Sambar sightings in that month. The Sambar would have used the riverine system as a conduit for such a migration.

The migration of Sambar in this study fits very well with the observations by Comte et al. (2022). Using camera trapping, Comte et al. (2022) observed Sambar were mostly absent from their study areas when snow occurred on the ground, from July to September. They suggested the Sambar had moved to lower elevations during winter, using road networks as their conduit. In their methodology, Watter et al. (2020) stated that Sambar at elevations above 1400 m in Victoria migrated to lower elevations in winter, and returned in late spring to follow snowmelt. However, they did not state how they determined this. In Taiwan, Yen et al. (2019) used GPS collars on 6 male and 6 female Sambar, the largest native herbivore species there, and demonstrated that they migrated back and forth from higher elevations in the hot-wet season to lower elevations in the cold-dry season over a 40-month period.

Other deer species also migrate; for example, Red Deer *Cervus elaphus* and Roe Deer *Capreolus capreolus* in Europe (Peters et al. 2018) and White-Tailed Deer *Odocoileus virginianus* (Nelson et al. 2004) and Mule Deer *Odocoileus hemionus* in the United States of America (Nicholson et al. 1997). The primary reason for migration of these deer species was access to emerging feed, resulting in deer migration in the northern hemisphere being described as 'surfing the green wave' (Aikens et al. 2020). Similarly, in their study in Victoria, Watter et al. (2020) intimated this is the reason for Sambar migration in that state.

Effects of fire and culling

Much of the Sambar habitat in Victoria (6691500 ha, Forsyth, Stamation and Woodford 2015; 7000000 ha, Watter et al. 2020) was burnt in the Black Summer bushfires of 2019/2020. The Eastern Victorian Sambar Deer population represents >99% of Sambar distribution in Victoria. Considering the extent of the fires on the study site (80%), and that more than half the East Gippsland LGA burnt (1363100 ha; Community Bushfire Connection 2022) in these fires, a decrease in Sambar sightings was expected at the study site in 2020, but this did not occur. However, Forsyth et al. (2012) found Sambar pellets decreased to zero following the 2009 Black Saturday Bushfires in Kinglake National Park, although they returned to only slightly reduced pre-fire counts 16 to 24 months after the fire. Based on anecdotal reports, Davis et al. (2016) stated that fire caused shifts in the home ranges of deer, as they fled the fires and found food and water in unburnt areas.

A significant increase in Sambar sightings occurred at the study site in 2020 (Fig. 2), despite the fires and the cull carried out by DELWP from 10 February to 8 May 2020 (DELWP 2020). The cull focused on Alpine Bogs, the Snowy River Corridor and the Howe

Wilderness/Howe Flat, although priority areas were expanded during the course of the cull. Of the 1558 target animals killed, 1434 were Sambar Deer (DELWP 2020). Further culling continued into 2021 so that a total of 5300 Sambar were killed between February 2020 and June 2021 (Kaustav Dahal, DELWP, pers. comm. 2021). The Snowy River Valley was one of the target sites. At its closest point, the Snowy River Valley is 18 km from the survey site, thus the cull had the potential to impact this study.

Most of the deer's habitat on the property had been burnt except for a small, heavily wooded area in the northwest, which abutted an area of unburnt crown land. This unburnt area on the property may have been a contributing factor to the increased Sambar sightings in 2020 surveys, as the Sambar seen that year appeared to have sought refuge there. Much suitable habitat for shelter and camouflage was burnt in the EGBS fires, so Sambar and other animals would have been concentrated in unburnt pockets of available habitat. Heavy rains (80 mm) fell at the study site 2 weeks after the fires, and vegetation (deer food) regenerated shortly afterwards, thus the availability of food and shelter could explain the increased numbers of Sambar.

The expected drop in Sambar sightings occurred in 2021 (Figs 2 to 4; Table 2). Whether this was a delayed result caused by the fires or the culling is difficult to say. It is unknown how many Sambar perished in or as a result of the fires. Harvesting by deer hunters was more than halved in 2020 (50 635 Sambar; Moloney and Flesch 2021) compared to that in 2019 (131 300 Sambar; Moloney and Hampton 2020). The number of Sambar culled does not make up the difference in Sambar shot by hunters in these years, so culls may not account for the sudden drop in Sambar sightings in 2021, although they would be a contributing factor. The extent of their contribution could be determined by establishing how many Sambar were shot in the Snowy River Valley during the cull, and how many were shot by deer hunters in this particular area, and the timing of these 2 factors in relation to the survey period in 2021. Other contributing factors are likely. For example, feed would have replenished to various extents in burnt areas by 2021, and there would be areas where regrowth was sufficient to provide shelter, enabling surviving Sambar to spread further than they could immediately after the fires.

Conclusion

Although this was a small, opportunistic study, it has revealed several key points. The increase in Sambar on this private property correlated well with that occurring elsewhere in the state. Sambar were more approachable when the surveyor was on a quad-bike than when on foot, making quad-bikes a useful tool for on-ground observational research. However, this would be dependent on whether the Sambar had been hunted with a quad-bike as the vehicle in use. This, as far as the author is aware, is the first time Sambar have been reported to habituate to surveyor presence. Identification of individual Sambar by distinctive antler shape and scarring can prove useful for behavioural research. Sambar migrated from the high country to a warmer environment in response to snowfall and returned to the high country in September. It is unclear what effects fire and culling have had on reducing Sambar numbers on the property, but both are likely to be contributing factors.

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Received 11 November 2021; accepted 23 July 2022

Return of the Superb Lyrebird *Menura novaehollandiae* to the Bend of Islands and Warrandyte State Park: evidence of a functional Kinglake–Warrandyte wildlife corridor

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Abstract
Wildlife corridors are recognised for their many benefits to nature and society, while also proposed to be a method used to conserve or recover wildlife populations in peri-urban environments. The public land connecting Kinglake National Park to Warrandyte, north east of Melbourne, is one such wildlife corridor. Here, we present contemporary records and results of long-term monitoring of the ensuing establishment of the Superb Lyrebird *Menura novaehollandiae* in the Bend of Islands, north east of Melbourne. This recolonisation event follows a multi-decade regeneration after local extirpation that was caused probably by historical land clearing and a large wildfire in 1962. This study also documents the first contemporary breeding records for Superb Lyrebirds in the Bend of Islands, suggesting that this corridor has facilitated permanent recolonisation of regionally significant fauna to the area. (*The Victorian Naturalist* 139(5), 142–149)

Keywords: Wildlife corridor, peri-urban wildlife, Superb Lyrebird

Introduction

The Kinglake–Warrandyte wildlife corridor

Wildlife corridors are intended to maintain biotic populations, communities and ecological processes in landscapes that are fragmented by human activity (Bennett 1999). A habitat corridor is defined as a linear strip of vegetation that provides a continuous pathway between two habitats (Bennett 1999). The concept has been embraced by land managers and communities as one solution to biodiversity loss in developed landscapes across Australia (Whitten et al. 2011). However, the effectiveness of a corridor to support the movement of biota depends on many factors. Structural components of the habitat, coupled with the physiological and behavioural traits of biota, determines functionality. Spatial organisation of the vegetated area (e.g. length, width, edge complexity) along with landscape context (e.g. topography, successional stage of connected habitats, surrounding land use) may influence an organism's ability or willingness to move from one habitat to another (Rosenberg et al. 1997). For some species, a corridor may constitute permanent habitat that fulfills all their needs for survival, foraging and reproduction, while for others, a corridor may be used only as a transitory pathway, representing relatively hospitable space to move between larger areas of habitat (Rosenberg et al. 1997).

In the landscapes of Greater Melbourne, the Yarra River, and its major tributaries, provide important wildlife corridors. At present, these areas are managed primarily for biodiversity (Knight 2017; Coleman and Amenta 2002). The Kinglake–Warrandyte wildlife corridor is one example, linking the wet mountain forests of Kinglake with foothill and valley forests along the Yarra River at Warrandyte State Park (Fig. 1). This area represents a diverse and unique range of connected habitat types, running along a latitudinal and elevational gradient (Beardsell 1997). Though not a formal reserve, the habitat corridor comprises several smaller reserves, private holdings and the Sugarloaf Reservoir. Typical of semi-rural landscapes in the region, the spatial configuration of the corridor is complex, with significant tracts of native vegetation bordered by Watsons Creek, Panton Hills and St Andrews to the west, and the Yarra Valley townships of Yarra Glen and Steels Creek to the east. Land throughout the Christmas Hills represents a patchwork of native vegetation,

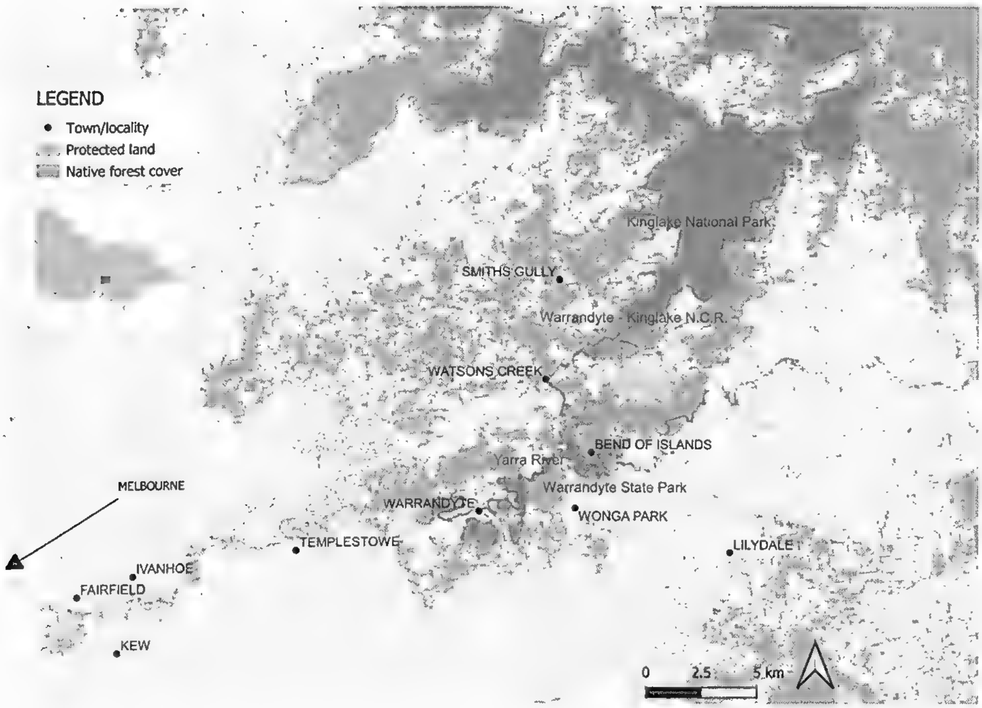

Fig. 1. Location and landscape context of the Kinglake–Warrandyte wildlife corridor, comprising the Warrandyte–Kinglake Nature Conservation Reserve and other forested areas, linking Kinglake National Park with Warrandyte State Park along the Yarra River. Light shaded areas within the corridor are generally semi-rural land with substantial areas cleared of native vegetation.

interposed with low-density housing and cleared smallholdings.

The Kinglake–Warrandyte wildlife corridor provides habitat for several faunal and floral species of state and regional significance, including the Powerful Owl *Ninox strenua* (Lavazanian et al. 1994, Bradsworth et al. 2017) and Brush-tailed Phascogale *Phascogale tapoatafa* (Scida and Gration 2018), along with a number of threatened orchid species. While wide-ranging birds such as the Powerful Owl may easily traverse disturbed and fragmented landscapes, species that are ground-foraging and restricted to forest habitats are likely to require more specific habitat qualities. The Superb Lyrebird *Menura novaehollandiae* is one such species, and despite being a predominantly wet forest species, is now utilising the relatively dry vegetation communities throughout the Kinglake–Warrandyte reserve system (Beardsell 1997).

Historical records of Superb Lyrebird

Historically, the Superb Lyrebird has been recorded along the Yarra River close to Melbourne (Beardsell 1997); however, accurate records and locations are difficult to determine. In an interview conducted by Cam Beardsell in the 1980s, artist and environmentalist Neil Douglas reported that he recorded Lyrebirds near the Yarra River in the Bend of Islands, across the river from what is now the Mt Lofty section of the Warrandyte State Park, prior to the year 1962. In that year, severe fires swept through the area, and Lyrebirds had not been there since (pers. comm. Cam Beardsell 2020). Given that Lyrebird habitat is negatively impacted by severe bushfire (Nugent et al. 2014), it is likely that the burned habitat became unsuitable for some time following the fire. With the concurrent development of farmland within and surrounding the Christmas Hills, it is perhaps unsurprising that the Lyrebird was lost from the regions' biota.

In the ~40 years following this fire, natural regeneration increased the connectivity of habitat between Kinglake National Park and Warrandyte State Park. In 1976 the Bend of Islands Conservation Association worked with the Healesville Shire Council to implement a unique Environmental Living special use zone to foster Residential Conservation. Controls were instigated to minimise the impact of low-density residential occupation and to protect and enhance the natural environment. This Special Use Zone is now included under the Shire of Nillumbik Planning Scheme.

Here, we report on the return and re-establishment of the Superb Lyrebird to this region, documented over the past 20 years.

Methods

Study site

The Bend of Islands Environmental Living Zone (ELZ) is an area of 634 hectares of natural bush and residential land located 35 km north east of Melbourne. Primarily managed for nature conservation, while allowing for low-impact, low-density living, the area is zoned Special Use Zone 2 (Environmental Living) under the Shire of Nillumbik Planning Scheme. Management controls have been developed to maintain and enhance the positive environmental qualities of landscape, vegetation, habitat for flora and fauna, and to protect specific sensitive areas from damage to the natural systems, consistent with the maintenance of existing human occupation. This includes controls over vegetation clearing, exclusion of most domestic animals, and limitations on fencing and the planting of species not indigenous to the local area.

The Bend of Islands supports the following eight Ecological Vegetation Classes (EVCs): Box Ironbark Forest (EVC 61); Creekline Herb-rich Woodland (EVC 164); Escarpment Shrubland (EVC 895); Grassy Dry Forest (EVC 22); Herb-rich Foothill Forest (EVC 23); Riparian Forest (EVC 18); Swampy Riparian Complex (EVC 126), and Valley Grassy Forest (EVC 47). Box Ironbark, Creekline Herb-rich Woodland and Valley Grassy Forest have a bioregional conservation status of Vulnerable in the Highlands–Southern Fall Bioregion, whilst Escarpment Shrubland is regionally endangered (Jolly and Osler 2012).

Unsurprisingly, the majority of Lyrebird records are concentrated in the areas of Riparian Forest, Creekline Herb-rich Woodland and adjacent Herb-rich Foothill Forest (Fig. 2).

The local Landcare Group and residents have limited resources, so the general approach is to encourage natural regeneration as much as possible and to try to limit weed incursion and other detrimental effects throughout the entire area. Management activities, assisted by grants when available, include woody weed control, targeted weedy grass control and some targeted planting of locally threatened species.

Lyrebird records

Following the first contemporary sighting of a Lyrebird in the corridor during the year 2000, one of the authors (FP) began recording (in an excel database) each occasion that a Lyrebird was seen or heard. In the subsequent years, residents of the ELZ and local naturalists were encouraged to contribute their records of Lyrebirds to this database. Each record included the time and date the Lyrebird was detected, the name of the recorder, the location and whether the bird was seen or heard. Lyrebird records are being collected on an ongoing basis. Additionally, each record was plotted on a map of the ELZ and surrounds (Fig. 2).

The Victorian Biodiversity Atlas (VBA) is a government database that includes expert-verified records of flora and fauna collected by researchers and members of the public. On 4 March 2022, this database was searched for all Lyrebird records in a 40 km^2 area (represented by the mapped area in Fig. 2) for comparison with our own database.

Results

On 16 July 2000, one of the authors (FP) recorded a Lyrebird in the Bend of Islands ELZ. This observation was recorded in the same week as the only pre-existing Lyrebird record included in the VBA for the study area (Observation ID: 467449; 13 July 2000) and is almost certainly the same individual. Following these significant sightings, over 400 records have been collated. Our search of the VBA revealed 10 Lyrebird records for this area between the years 2000 and 2021. Subsequent to the early records (preceding 2004), Lyrebird sightings have remained

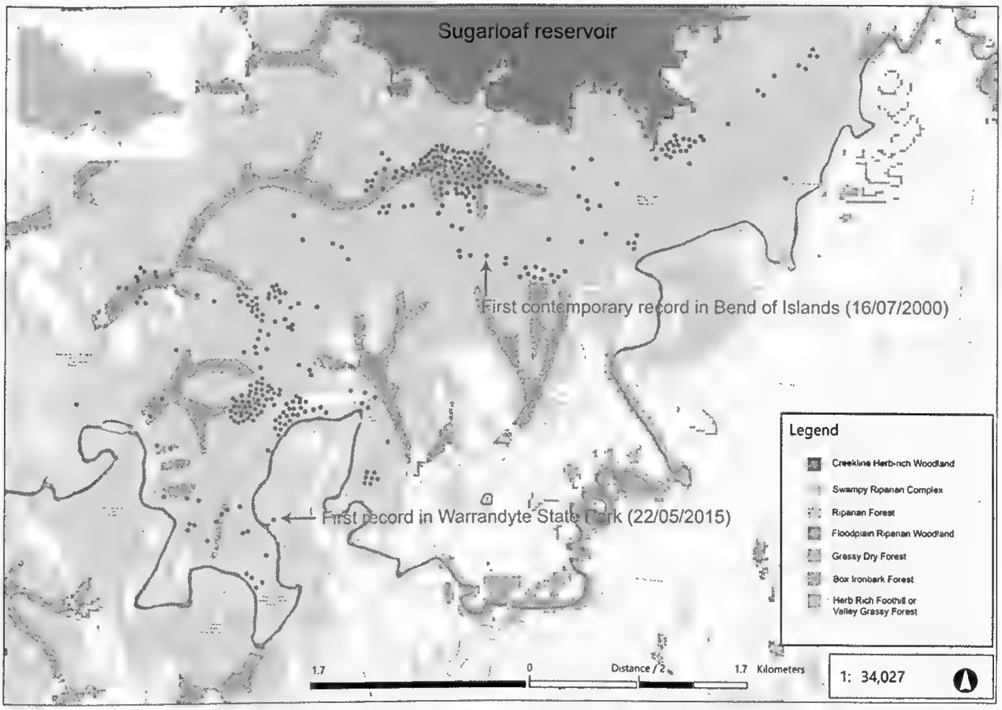

Fig. 2. Map of the Bend of Islands Environmental Living Zone and surrounds with the approximate location of Superb Lyrebird *Menura novaehollandiae* records marked in red (2020 breeding observations not shown).

relatively consistent throughout most of the survey period, with a notable spike in records during the summer months at the beginning of 2006 (Fig. 3). Most sightings occurred during the non-breeding season (Table 1), possibly because Lyrebird territory boundaries are relaxed over the summer period (Ashton and Bassett 1997), thus resulting in more movement across the wider landscape. Moreover, many of the key local recorders tend to be away for extended periods in the winter months, thus decreasing the rate of recording.

On 22 May 2015, the first record of a Lyrebird was made on the southern side of the Yarra River, in Warrandyte State Park. A local resident, experienced in bird identification, heard a Lyrebird calling and went to the river to investigate and establish that the bird was indeed south of the river in Warrandyte State Park.

Breeding records

A disused Lyrebird nest was located in a small tree adjacent to Stevenson Creek, on 2 February 2020. This nest had been observed by FP in January 2016, so would have been active during the winter of 2015 or before. This is the first breeding record for Lyrebirds within the ELZ. A second disused Lyrebird nest was located in a large tree some 40 m north of Stevenson Creek, on 23 May 2020.

On 13 June 2020 an active nest was found on an exposed rock ledge adjacent to Stevenson Creek (Fig. 4a-b). The nest was monitored with carefully-placed remote-sensing cameras to avoid disturbance to the female Lyrebird. The bird produced an egg on about 27 June 2020. On 2 separate occasions during the incubation phase, a Brown Goshawk *Accipiter fasciatus*, a known predator of Lyrebird eggs (Maisey et al. 2016), triggered the cameras while inspecting the nest and egg within (Fig. 4c). The different sizes of the birds in the images suggested that on one occasion the bird was male and on another occasion the bird was female. Surprisingly, the predators did not depredate the nest on these occasions; the egg remained.

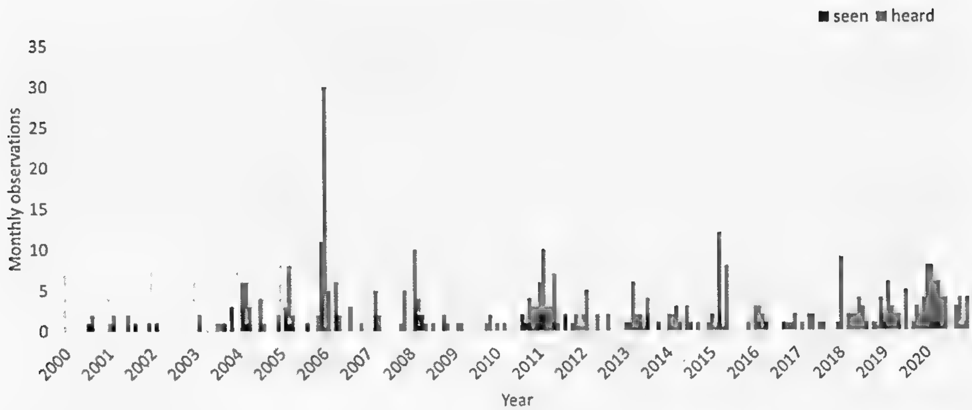

Fig. 3. Graphed monthly Superb Lyrebird records in Bend of Islands Environmental Living Zone (2020 breeding observations not shown).

Table 1. Total monthly Superb Lyrebird *Menura novaehollandiae* records for all years combined (2000–2020), excluding 2020 breeding observations.

Month	Heard	Seen
January	64	3
February	51	16
March	53	9
April	26	9
May	29	3
June	14	1
July	16	5
August	9	8
September	5	3
October	16	3
November	22	3
December	26	8

After 42 days, on 8 August 2020, a chick hatched from the egg. On 26 August 2020 at 1832 hrs, a European Red Fox *Vulpes vulpes* triggered the camera as it depredated the Lyrebird chick (Fig. 4d). By this stage of chick development, the adult female was no longer brooding overnight.

Corridor use by other species

Further indication that the wildlife corridor provides a functional link with Kinglake is the presence of the call of the Eastern Whipbird *Psophodes olivaceus* among the mimetic items identified in the Lyrebird repertoire at the Bend of Islands. Whipbirds had rarely been recorded in the Bend of Islands since the 1962 fires. Given the high detectability of the song of this species, it is likely that this reflected a true absence of a Whipbird population. The calls of the Eastern Whipbird were detected in the repertoire of a Lyrebird on 13 January 2006, 5 March 2008 and 23 February 2011, suggesting the individuals mimicking the Whipbird had either originated in Kinglake National Park where the Eastern Whipbird persists, or learned the call from other Lyrebirds that had originated there. Since 20 December 2020, an Eastern Whipbird has been recorded on 22 occasions along Watsons Creek in the Bend of Islands. These appear to be the first known records, away from the Yarra River, in the Bend of Islands since before the 1962 fires and are another example of the value of the Kinglake–Warrandyte wildlife corridor.

Other significant species recorded in the ELZ that are assumed to be making use of the corridor include Lace Monitor *Varanus varius* (a threatened species in Victoria) and Red-browed Treecreeper *Climacteris erythrops*.

Conclusions

This study presents the first record of a Lyrebird south of the Yarra River in Warrandyte State Park, since the last large fires in 1962. Our records provide strong evidence that the Kinglake–Warrandyte wildlife corridor is functioning to facilitate recolonisation by the Superb Lyrebird, with a resident population now established and indeed breeding in the Bend of Islands ELZ. Further, this highlights the benefits

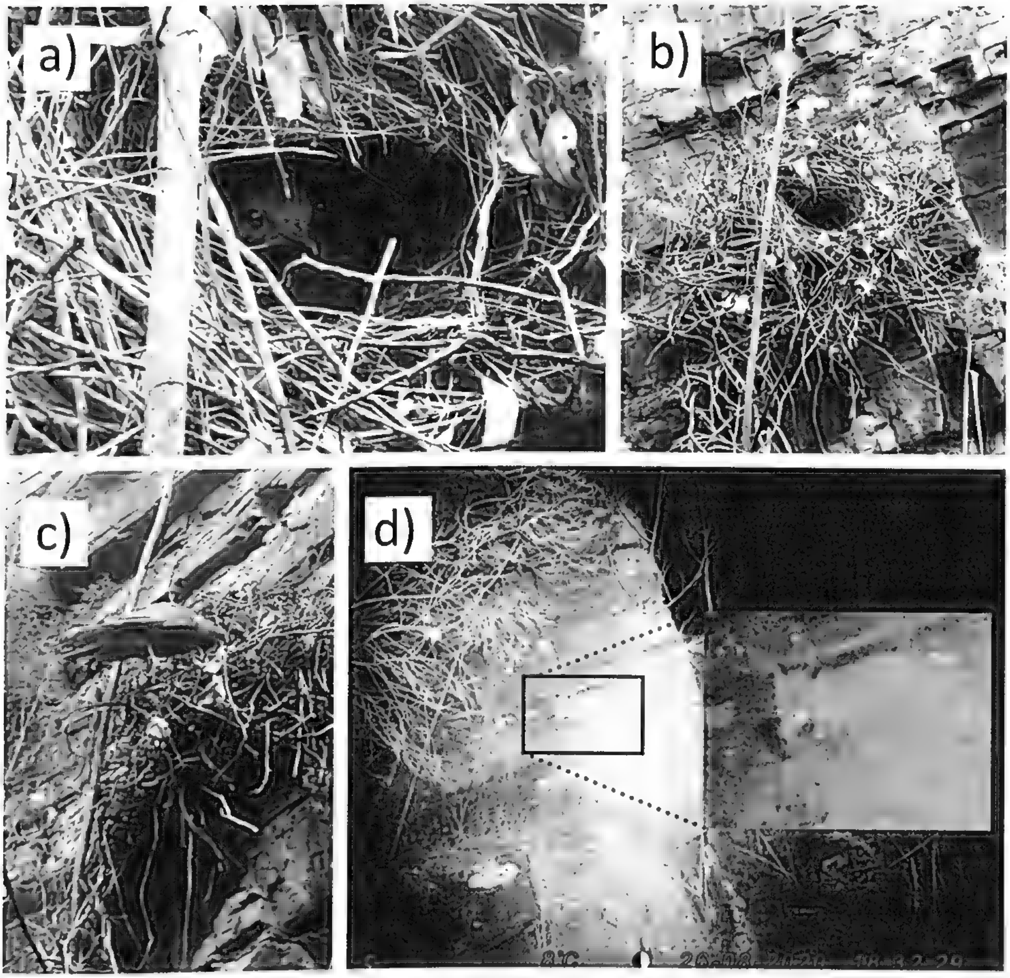

Figure 4. a) Female Superb Lyrebird *Menura novaehollandiae* visible within nest while incubating the egg; b) completed Lyrebird nest in the Bend of Islands Environmental Living Zone on 13 June 2020; c) Brown Goshawk *Accipiter fasciatus* on the entrance to the nest containing the egg; and d) European Red Fox *Vulpes vulpes* depredating the 18-day-old Lyrebird chick.

to wildlife of a community-led ELZ that is supported by local government. With strong planning protections from local government and smaller-scale but widespread effort to protect and enhance habitat, the Bend of Islands ELZ has been restored to a condition suitable for the habitation and importantly, reproduction, of Superb Lyrebirds.

Importance of the Superb Lyrebird as an ecosystem engineer

A seldom considered, yet important role of wildlife corridors is to maintain ecosystem function. Despite the difficulty in predicting when and how a corridor aids ecological function, if the corridor facilitates the movement of animals that are ecosystem engineers (i.e. organisms that modify the physical environment in ways that alter availability or quality of habitat for other species; Jones et al. 1994), ecological function may be improved. The Superb Lyrebird is recognised as an ecosystem engineer owing to the immense volume of soil turned over when foraging (Maisey et al. 2020). Extensive modification of the litter layer by Lyrebirds gives rise to multiple niche habitats

available to invertebrates and microbial communities that would not exist in the birds' absence. Lyrebird foraging increases nutrient breakdown and therefore may even change fire behaviour in forests where Lyrebirds are active (Nugent et al. 2014). With the recolonisation of the ecosystem by Lyrebirds, ecological function will potentially be improved and may benefit other biota (e.g. fungi, macroinvertebrates).

Management implications

In the face of urbanisation, invasion by pest plants and animals, and impacts of climate change, corridors along elevational and latitudinal gradients will become more important to biota. This corridor provides a valuable link between the Yarra River at the Bend of Islands and the mountainous habitat within Kinglake National Park, while facilitating the movement of rare and iconic wildlife to the edges of peri-urban Melbourne. The corridor therefore confers both high conservation and social values to the region.

Management actions to mitigate the impacts of predators on Lyrebirds, such as control programs for the Red Fox in the Bend of Islands and adjacent areas, are likely to be beneficial to Lyrebird populations. In the peri-urban environment of the Dandenong Ranges, east of Melbourne, Fox control over many decades has been attributed to recovery of Lyrebird populations (unpublished data, Sherbrooke Lyrebird Survey Group). Regional programs to enforce greater domestic pet control (e.g. 24/7 cat containment bylaws) would also decrease predation pressures on Lyrebirds, particularly young ones.

The Bend of Islands has benefitted from a major grant that was expended between 2017 and 2020 (The Sugarloaf Link Project, provided by DELWP, administered by Nillumbik Shire), which achieved significant control of woody weeds, deer and Foxes. The findings of this study highlight the need for ongoing Fox control for long term Lyrebird survival. The need for ongoing management of the Bend of Islands and the Kinglake–Warrandyte wildlife corridor is also highlighted as being important for the achievement of the 50-year vision of the Yarra Strategic Plan 2021 (Melbourne Water 2022).

This study provides evidence of a functional wildlife corridor that appears to have facilitated recolonisation of the Bend of Islands by Lyrebirds and Whipbirds, following local extirpation caused by historical land clearing and a severe bushfire. In the context of the recent Black Summer fires, in which ~7.2 million ha of forest were burned in eastern Australia (Nolan et al. 2021), recognising the value of wildlife corridors is paramount. Wildlife corridors, as important features of highly modified landscapes, will play an increasingly critical role in the recolonisation and recovery of many faunal populations following fire.

Acknowledgments

We thank all the residents of the ELZ who contributed their records of Lyrebirds in the study area.

The Bend of Islands Conservation Association is thanked for its ongoing efforts to protect and enhance the ELZ and, especially in this case, for facilitating the communication of progressive updates on Lyrebird activities to the community through its newsletters, which stimulated such useful community feedback.

The Shire of Nillumbik is thanked for its ongoing support and assistance to the Bend of Islands Conservation Association for environmental monitoring and management of the ELZ.

Monitoring and records were collected by the author (FP) under the Flora and Fauna Guarantee Act, and Wildlife Act Permit # 1009192 and Wildlife and Small Institutions animal ethics approval Nillumbik 19.19.

The comments from an anonymous referee are also gratefully acknowledged.

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Received 20 January 2022; accepted 5 March 2022

Partnerships everywhere: examples of mutualistic interactions in urban and suburban environments

Mutualism is an association between organisms such as animals and plants, where both partners benefit from their relationship (Parmentier and Michel 2013; Dunkley et al. 2020). Mutualistic interactions are widespread and essential to the biodiversity and maintenance of ecosystems. Most mutualisms are service-resource relationships, in which services such as flower pollination, seed dispersal and cleaning symbiosis are traded for food such as nectar, fruit pulp and parasites (Van der Pijl 1972; Faegri and Van der Pijl 1979; Vaughan et al. 2017; Dunkley et al. 2020). These partnerships are found in all environments, including those modified by human activity (Loyn and French 1991; Vaughan et al. 2017; Dunkley et al. 2020). Here, we briefly describe and illustrate a few different examples of mutualistic interactions easily observed in suburban and urban environments. These examples include interactions as different as animals and plants, animals and animals, fungi and animals, and fungi and algae.

We walked daily at Wentworth Point and environs in the Sydney suburban area, searching for organisms visible with the unaided eye. We surveyed blooming and fruiting plants, searching for nectar- and fruit-feeding birds. We watched fishes and searched for interactions. We also looked for fungi on the ground, watching for visiting insects. The relationships between all the observed organisms were documented with a 70–300 mm lens digital camera and analysed later.

Bird visits to flowers were the most common instances of mutualistic interactions observed. We illustrate here the Rainbow Lorikeet *Trichoglossus moluccanus* visiting Saw Banksia *Banksia serrata* (Fig. 1). While the bird laps the nectar from flowers, its body parts come in contact with the reproductive parts of the flower and usually pollen adheres to its feathers, pollinating the flowers. After the Lorikeet ends the visit to one banksia tree, it usually flies to another and pollinates its flowers with pollen from previously visited trees.

Fig. 1. Flower pollination: the Rainbow Lorikeet *Trichoglossus moluccanus* laps nectar from Saw Banksia *Banksia serrata* flowers; pollen will be transported by the bird to another *B. serrata* tree during subsequent foraging activity.

Another commonly seen example of mutualistic interactions between birds and plants is the dispersal of seeds. We illustrate here the fruits of the Barrier Saltbush *Enchylaena tomentosa* plucked and swallowed by the Silvereye *Zosterops lateralis* (Fig. 2). The seeds will be regurgitated later and usually away from the mother plant. The greater the distance, the better for the seeds, as they may germinate and colonise new areas or environments.

Cleaning symbiosis is a textbook example of mutualism. A fish species (the cleaner) feeds on parasites from diverse fishes (the clients), thus ridding them of these pests. We illustrate here the Silver Batfish *Monodactylus argenteus* cleaning Yellowfin Bream *Acanthopagrus australis* in an urban estuary (Fig. 3). Only juvenile Batfish clean. The clients signal their readiness to be cleaned by adopting a head-down posture. The signal is picked up by the Batfish, which inspects and cleans the client —an example of communication between different animal species.

Dispersal of fungi spores by flies and other insects may be, to a certain extent, compared to plant seed dispersal by birds. When mature, some fungus species produce a putrid odour similar to that of rotten meat or other decaying organic matter, which attracts carrion-seeking blowflies (Calliphoridae). We illustrate here the Anemone Fungus *Aseroë rubra* being visited by the Calliphoridae flies *Chrysomya* sp. or *Lucilia* sp. (Fig. 4). This fungus produces a huge number of spores within a dark slime called gleba, which adheres to the legs of flies while they feed on it. Both the ingested spores and those clinging to the flies are then carried to other sites.

Lichens are an emblematic example of mutualism. They are composed of closely interacting organisms—a fungus and one or more algae or cyanobacteria. The fungus builds the structure of the lichen thallus, which provides conditions for its partner to thrive on inhospitable surfaces such as rocks or mortar. In turn, the algae photosynthesise sugars that nourish the fungus with the carbon it needs. We illustrate here this mutualism with the foliose lichen of the family Parmeliaceae growing on a path made up from asphalt and small rock pieces (Fig. 5), a surface on which neither the fungus nor the alga could survive in isolation.

Fig. 2. Seed dispersal: the Silvereye *Zosterops lateralis* swallows the fruit of the Barrier Saltbush *Enchylaena tomentosa* whole, and later regurgitates the seed away from the mother plant.

Fig. 3. Cleaning symbiosis: the Silver Batfish *Monodactylus argenteus* plucks parasites from the back of a head-down posing Yellowfin Bream *Acanthopagrus australis*. Note other bream posing and waiting for their turn to be cleaned.

Fig. 4. Spore dispersal: while blowflies *Chrysomya* sp. or *Lucilia* sp. (the metallic greenish ones) feed on the gleba of the Anemone Fungus *Aseroë rubra*, some of their body parts become coated with spores that will be carried to other sites.

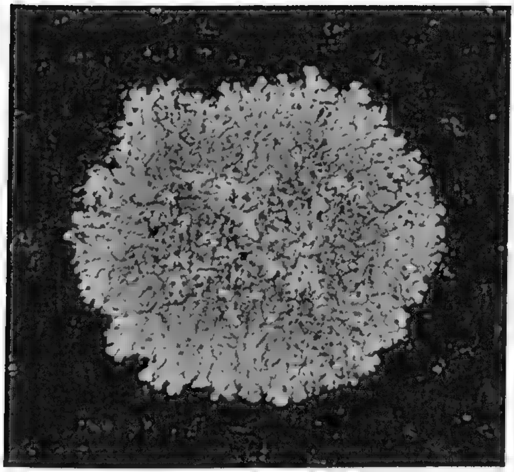

Fig. 5. A close-fitting mutualism: the foliose lichen of the family Parmeliaceae grows on a path of asphalt mixed with small rock pieces.

Flower pollination and seed dispersal by birds are two common mutualistic interactions in urbanised areas of Australia, and both the Rainbow Lorikeet and the Silvereye are found in cities (Caterall 2010; Adams 2018). However, cleaning symbiosis in brackish waters is an uncommon mutualism, where the Silver Batfish services mostly mullet and bream (Sazima 2021). Fungal spore dispersal by flies is well known in stinkhorns (Phallaceae), which may smell of rotting meat (Bunyard 2007). Fungi play essential roles in urban and suburban ecosystems (Stevenson et al. 2020). Lichens are bio-indicators of urban heat islands (Munzi et al. 2014) and monitor air pollution and climate change (Kuldeep and Prodyut 2015).

Lastly, the organisms here mentioned retain their ecological functions in suburban and urban areas, and provide regulating and supporting ecosystem services in the form of pollination, dispersion, and genetic diversity, as well as cultural services in the form of aesthetic inspiration and recreation (Stevenson et al. 2020). Watching the mutualistic interactions between organisms such as those described and illustrated here offers a touch of beauty and delight available to everybody.

Acknowledgements

We thank Barbara (surname unkown; The Royal Botanic Garden, Sydney) for helping with fruit identification, and Ciaran Mathewson (Australian Museum) for helping with fly identification. We also thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for grant 300992/79-ZO (IS) and grant 302781/2016-1 (MS). We acknowledge our former employer, the State University of Campinas, Brazil, where IS worked in the Department of Zoology and MS in the Department of Plant Biology.

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Dawn till Dusk in the Stirling and Porongurup Ranges

by Rob and Stuart Olver

Publisher: *Dawn till Dusk Publications, Murwillumbah, NSW 2484. Second Edition, 2020.*
164 pages, paperback, colour photographs throughout, 3 maps.
ISBN: 9780646824758. RRP: $49.95.

Brothers Rob and Stuart Olver have produced a second edition of their book, *Dawn till Dusk in the Stirling and Porongurup Ranges,* first published by UWAP in 1998. Lavishly illustrated with photographer Rob Olver's atmospheric images, it provides a broad introduction and guide to a highly significant region in the South West of Western Australia. In order of appearance, its themes include Aboriginal and European history, geology, climate, fauna, flora, facilities, scenic drives, bushwalking trails, rock climbing, gliding and other recreational activities, supplemented by a short section on place names and a glossary of bushwalking and climbing terms.

After moving to Australia from South Africa, the teenaged Olver brothers' first foray into the mountains was in 1985, and Rob later lived in the Porongurups from 2008 to 2011. Armed with his first camera, Rob's discovery of the landscape through mountain climbing and bushwalking provides the personal focus for this book. Other historical, scientific and recreational interests seem to have followed.

The book is beautifully designed, well written and well edited. It has an obvious appeal to adventure tourists but there is plenty of useful information for naturalists who read past the preface and introduction. Rather oddly (from a naturalist perspective), these fail to mention the unique botanical status of the ranges.

Stirling Range National Park has had a National Heritage listing since 2006 and is an important asset in identifying the South West as one of 34 global 'hotspots' for plant biodiversity. Historical exploration of the region's flora is discussed in Chapter 2 (European Settlement) while Chapter 6 (Plant Life) details important plant communities and their locations. Here we learn that Stirling Range has over 1500 plant species, of which an amazing 87 are endemic, and the much smaller Porongurup range boasts 700 plant species. Stirling Ranges' geographically isolated, rare banksias and *Darwinia* Mountain Bells on the higher peaks, along with 123 species of orchid, are key attractions for visitors.

In Chapter 1, on Aboriginal (Noongar) history, foundation stories are given for Stirling Range, originally and appropriately known as Kookangaarap (Koi Kyeunu-ruff), meaning 'place of ever moving fog and mist' (p. 11). Borongur-up (Porongurup) refers to the sacred nature of the smaller range, translating as the dwelling place of totem spirits or Borongur (p. 11). This chapter is brief, reflecting the loss of traditional knowledge after colonial-induced dispersal and the sparsity of historical records, particularly of Noongar tribal groups living around the Porongurups (p. 13).

Chapter 5 demonstrates that land clearance, changed fire regimes and introduced fauna were disastrous for much indigenous wildlife (p. 48). Since the establishment of Albany (then King George Sound) in 1826, 18 mammal species have become locally extinct, and some iconic birds, such as Malleefowl and Stone Curlew, may also have disappeared. The ranges provide vital habitat for relict mammals such as tiny Honey and Pygmy Possums, birds (including Baudin's and Carnaby's Black Cockatoos), numerous frogs, reptiles, invertebrates, and two recently reintroduced marsupial species, Numbats and Dibblers.

The evolution of these ranges as national parks is described in Chapter 2, beginning with the creation of Red Gum Spring Reserve in 1885 and establishment of Stirling Range National Park in 1913 (smaller than its current size but then just the third national park in Australia), and culminating with the work of

Friends of the Porongurup Range (Porongurup Range National Park was gazetted in 1971 and subsequently enlarged by the group's purchase of more land).

Their differences in geology, climate and size are closely examined in Chapters 3 and 4. Although only 30 km apart, we learn that the granitic, domed Porongurups are far more ancient than the rugged Stirling Range and have considerably higher rainfall. The formation of the Porongurup Range has been linked to the formation of Gondwanaland when Australian and Antarctic landmasses collided in the Precambrian period; however, the Stirling Range began forming as sedimentary rock only when these plates began to drift apart (p. 37). The ranges' differing ages and soils help explain differences in vegetation: for example, humus-rich Porongurup loam, created by eroded granite, supports the only remaining stand of Karri forest away from the main belt further to the west (p. 38), while the plains and lower slopes of Stirling Range are dominated by mallee heath and mallee Jarrah (p. 59).

Armed with such useful knowledge, active readers are better equipped to tramp the mountains in search of flora, fauna, and sublime views, using route information in Chapter 9 to assess walk lengths, times, and levels of difficulty. Although the road maps in Chapter 2 are easy to follow, Chapter 9 provides only one half-page map detailing Stirling Range Ridge Walk, so dedicated walkers will need to buy supplementary maps before setting out. The book would also benefit from the addition of an index and list of references, which currently appear as endnotes.

Minor quibbles aside, I wish I had purchased this informative book before I visited Stirling Range; it would have helped me to plan my trip better and include more time to explore the Porongurups as well. After reading *Dawn till Dusk in the Stirling and Porongurup Ranges,* I can't wait for a return visit.

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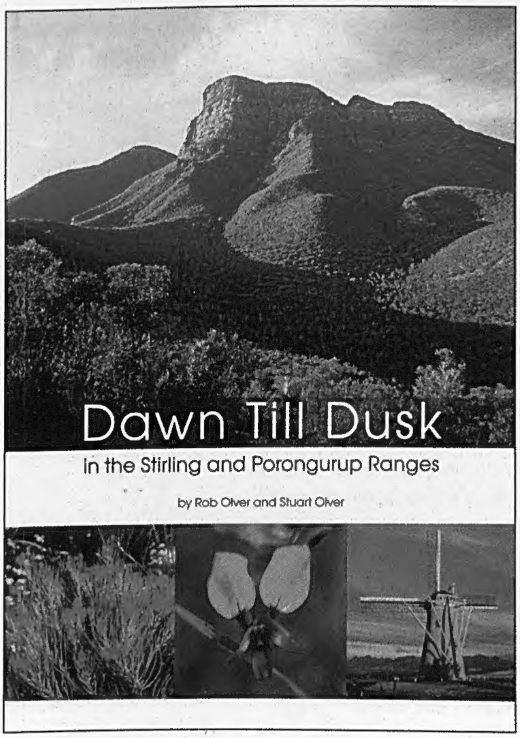

Nature unmasked: see and interpret Victoria's ecosystems

by Stephen Platt

Publisher: T*he author, Rosanna, Victoria 2021. 300 pages, paperback. RRP $35.00 (p/b);* a free digital version is available from <https://silverfoxyes.wixsite.com/nature/home>.

This new publication is a remarkable natural history treatise aiming to cover Victorian habitats, vegetation types and their associated plants and animals (to obtain a hard copy, see instructions on the website).Very different in approach and format from any other similar natural history publication, this book is a thoroughly fascinating account of the main habitats one can encounter. As a biologist, I found page after page described and documented new information and facts about a suite of the state's flora and fauna.

The author states in the opening pages (p. iii):

> This book is written for people who have a keen interest in nature and want to know more about it. It assumes very limited prior knowledge of the natural world. It's a book about how living things are connected with their environments and each other in Victoria.

Within the first 10 pages it was clear the author was achieving his aims and doing this in a very readable format. The style and quality of writing are of a high standard, and the information is clearly accurate, based on sound knowledge of resources and presented in an organised way.

Though quite long, at 300 pages, every chapter makes for an interesting read, providing the reader with endless opportunities to learn a bit more about the often unique flora and fauna we have in Victoria.

The book's 15 chapters commence and end with some thoughtful comments by the author. I'm sure many readers will find this gives them some understanding of Stephen Platt's deep knowledge and his love for the natural world. The Dedication section (p. iii) acknowledges this appreciation of others that have come before—something we rarely see in the majority of natural history books:

> To all those people who have a love of nature and who have contributed to its protection – your selfless efforts have given future generations the greatest treasure – life in all its wonderous diversity and beauty.

I found it refreshing to be advised of the author's approach at the start of the main chapters, e.g. (p. iii):

> ... I look broadly at some of the ecosystems that are easily recognisable and that have been studied. The book is not intended to be an exhaustive catalogue of all ecosystems.

The engaging chapter titles then follow a logical and well-thought-out format, as follows:

- Foreword
- I knew almost nothing
- The beginnings of ecology
- Understanding the shape of a gum tree
- River Red Gum – a forest of many floods
- A character shaped by fire
- Mallee – the great sand pit
- Grasslands – fire and volcanoes
- Alpine meadows – snow and ice
- Foothill forests – the gentle mosaic
- Box-ironbark forests and woodlands – the great honeypot
- The wet forests – remnants of times past
- Wetlands and estuaries – water supports life
- The coasts – where land meets sea
- Under the sea – our alien neighbours
- A new relationship with nature
- Now I know a bit
- Recommended reading
- References
- Index

The book is written in a way that enables interested observers at all levels to gain an understanding of the text and a sense of wonder at the same time. On page iii, advice on how to read the book is provided:

> Chapter covers invite you to look at an image and guess what is going on. An interpretation is given at the end of the chapter. A brief 'teaser' of interesting points starts each chapter. Details relating to these points are included in the chapter text. Chapters are perhaps best read when you are visiting the ecosystem.

A good way to start reading the book would be to go to a chapter covering a familiar part of the state, then proceed to other chapters for additional locations.

I can thoroughly recommend this arguably ground-breaking publication, which I feel could well become a benchmark and certainly a chief resource for naturalists, students, teachers and anyone who loves our different landscapes and wishes to gain a bit more knowledge in an easy to read format.

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